REMARKS

Claim 49 is amended. Claims 35-74 are pending in the application.

Claims 35-74 each stand rejected under 35 U.S.C. § 103(a) as being unpatentable over the combination of Besser, U.S. Patent No. 5,582,881; Shan, U.S. Patent No. 6,140,228; Colgan, U.S. Patent No. 5,925,933; and Marieb, U.S. Patent No. 5,909,639. The Examiner is reminded by direction to MPEP § 2143 that a proper obviousness rejection has the following three requirements: 1) there must be some suggestion or motivation to modify or combine reference teachings; 2) there must be a reasonable expectation of success; and 3) the combined references must teach or suggest all of the claim limitations. Each of claims 35-74 are allowable over the combination of Besser, Shan, Colgan and Marieb for at least the reason that the references, either independently or as combined, fail to teach or suggest each and every limitation in any of those claims.

With respect to independent claim 35, such recites depositing an aluminum material at a deposition temperature of at least 400°C to form a first layer and, without allowing the outermost portion of the deposited aluminum cool to below 360°C, depositing titanium on the aluminum material to form a second layer comprising an aluminum/titanium alloy which forms during the deposition of titanium. Claim 35 further recites depositing titanium nitride on the second layer. When claim 35 is considered as a whole, the combination of Besser, Shan, Marieb and Colgan fails to teach or suggest at least these recited features.

As noted by the Examiner at page 3 of the present action, Besser does not disclose or suggest the claim 35 first layer being deposited at a temperature of at least 400°C, or the recited deposition of a titanium comprising material without letting the outermost portion of the first layer cool. Shan discloses depositing aluminum or other metal by cold depositing a seed layer followed by hot depositing an additional quantity of the same metal (col. 6, ln. 31-37; col. 7, ln. 16-17; col. 8, ln. 41-44 and example 1). Shan does not disclose or suggest the claim 35 recited depositing an outermost portion of a first layer comprising aluminum at a temperature of at least 400°C and subsequently depositing titanium, or the recited forming an aluminum-titanium alloy during the titanium deposition. Accordingly, Shan does not teach or suggest the recited depositing titanium on a layer comprising aluminum and, as combined with Besser, cannot suggest the recited titanium-aluminum alloy formation during titanium deposition which occurs without allowing the aluminum comprising layer to cool below a temperature of 360°C.

Marieb discloses depositing a layer of titanium over an aluminum comprising layer and depositing a layer of nitride over the layer of titanium (col. 3, ln. 3-16). Marieb further discloses forming an additional titanium layer over the nitride layer and applying heat to the layers (col 3, ln. 23-34). Marieb does not disclose or suggest the claim 35 recited formation of a titanium aluminum alloy during the deposition of titanium wherein the titanium is deposited without letting the outermost portion of the aluminum layer cool to a temperature of below 360°C. As Marieb notes at col. 3, ln. 27-40, the application of heat to

the layers, which occurs after the deposition of titanium nitride results in the formation of a titanium-aluminum alloy between the titanium and the aluminum layers. As specifically discussed in applicant's disclosure at, for example, page 9, lines 1-6, the claim 35 recited titanium-aluminum alloy (which is formed during the deposition of the titanium) can shield migration of aluminum through a subsequently deposited titanium nitride layer during or after the titanium nitride layer formation. Accordingly, the post-titanium nitride deposition heating step disclosed by Marieb cannot suggest the claim 35 recited formation of a titanium aluminum alloy during deposition of titanium wherein the titanium is deposited on an aluminum layer without allowing the deposited aluminum to cool to a temperature below 360°C. Further, the post-titanium nitride heating step disclosed in Marieb when combined with Besser and Shan cannot suggest the claim 35 recited formation of an aluminum-titanium alloy during a deposition of a titanium comprising material wherein the deposited aluminum is not allowed to cool to a temperature of below 360°C.

Colgan discloses formation of an aluminum comprising layer followed by formation of a titanium layer and formation of a titanium nitride layer. Colgan further discloses a subsequent heating step which can react titanium with aluminum to form a titanium-aluminum alloy (col. 2, ll. 62 through col. 3, ll. 7; and col. 5, ll. 20-33). For reasons similar to those discussed above with respect to Marieb, Colgan does not teach or suggest the claim 35 recited aluminum-titanium alloy formation during deposition of titanium wherein the titanium is deposited without allowing the deposited layer of aluminum to cool below a

the layers, which occurs after the deposition of titanium nitride, results in the formation of a titanium-aluminum alloy between the titanium and the aluminum layers. As specifically discussed in applicant's disclosure at, for example, page 9, lines 1-6, the claim 35 recited titanium-aluminum alloy (which is formed during the deposition of the titanium) can shield migration of aluminum through a subsequently deposited titanium nitride layer during or after the titanium nitride layer formation. Accordingly, the post-titanium nitride deposition heating step disclosed by Marieb cannot suggest the claim 35 recited formation of a titanium aluminum alloy during deposition of titanium wherein the titanium is deposited on an aluminum layer without allowing the deposited aluminum to cool to a temperature below 360°C. Further, the post-titanium nitride heating step disclosed in Marieb when combined with Besser and Shan cannot suggest the claim 35 recited formation of an aluminum-titanium alloy during a deposition of a titanium comprising material wherein the deposited aluminum is not allowed to cool to a temperature of below 360°C.

Colgan discloses formation of an aluminum comprising layer followed by formation of a titanium layer and formation of a titanium nitride layer. Colgan further discloses a subsequent heating step which can react titanium with aluminum to form a titanium-aluminum alloy (col. 2, ll. 62 through col. 3, ll. 7; and col. 5, ll. 20-33). For reasons similar to those discussed above with respect to Marieb, Colgan does not teach or suggest the claim 35 recited aluminum-titanium alloy formation during deposition of titanium wherein the titanium is deposited without allowing the deposited layer of aluminum to cool below a

temperature of 360°C. Additionally, the subsequent heating step as disclosed in Colgan, when combined with Marieb, Besser and Shan, fails to teach or suggest the claim 35 recited aluminum-titanium alloy formation during deposition of titanium wherein the titanium is deposited after deposition of aluminum and without allowing the outermost portion of the deposited aluminum to cool to a temperature below 360°C.

As set forth above, the combined disclosures of Besser, Shan, Colgan and Marieb clearly do not suggest the claim 35 recited forming an alloy of titanium and aluminum during deposition of a titanium comprising material on a deposited aluminum material wherein the temperature of the outermost portion of the deposited aluminum is not allowed to cool to a temperature below 360°C. Additionally, these recited features confer specific benefits as set forth in the applicant's disclosure. As discussed above, the formation of an aluminum-titanium alloy during the deposition of titanium and prior to formation of any titanium nitride layer can inhibit or prevent migration of aluminum with respect to TiN during or after the formation of the TiN. Additionally, the recited method can prevent or inhibit the aluminum migration without requiring an additional cooling step since the aluminum is not allowed to cool below 360°C prior to depositing the titanium (see applicant's specification at, for example, pg. 3, ln. 5; pg. 2, ln. 21 through pg. 3, ln. 4; and pg. 9, ln. 1-6). Since the combined disclosures of Besser, Shan, Colgan and Marieb do not suggest the claim 35 recited features of forming a titanium-aluminum alloy during deposition of titanium and without allowing the deposited aluminum to cool below 360°C prior to the

titanium deposition, and since these features confer specific advantages, claim 35 is not rendered obvious by the combination of Besser, Colgan, Marieb and Shan.

Dependent claims 36-48 are allowable over the combination of Besser, Shan, Marieb and Colgan for at least the reason that they depend from allowable base claim 35.

Independent claim 49 is amended to provide proper antecedent basis for the recited "the second layer" at line 11. Independent claims 49 and 58 each recite depositing an aluminum comprising layer at a deposition temperature of at least 400°C and forming an aluminum-titanium alloy during a titanium deposition, wherein the titanium deposition is performed without letting the aluminum comprising layer cool to below a temperature of 360°C. Independent claims 49 and 58 are allowable over the combination of Besser, Shan, Marieb and Colgan for at least reasons similar to those discussed above with respect to independent claim 35.

Dependent claims 50-57 and 59-74 are allowable over the cited combination of Besser, Shan, Marieb and Colgan for at least the reason that they depend from corresponding allowable base claims 49 and 50.

For the reasons discussed above claims 35-74 are allowable. Accordingly, applicant respectfully requests formal allowance of claims 35-74 in the Examiner's next action.

Respectfully submitted,

Dated: 6-22-2002 By: Jennifer J. Taylor

Jennifer J. Taylor, Ph.D.
Reg. No. 48,711

Application Serial No. 09/785,858
Filing Date ..... February 16, 2001
Inventor ..... Leiphart, S.
Assignee ..... Micron Technology, Inc.
Group Art Unit 1753
Examiner ..... Cantelmo, G.
Attorney's Docket No. MI22-1636
Title: Method of Forming an Aluminum Comprising Line Having a Titanium Nitride Comprising Layer Thereon

VERSION WITH MARKINGS TO SHOW CHANGES MADE ACCOMPANYING RESPONSE TO MAY 22, 2002 FINAL ACTION

In the Claims

The claims have been amended as follows. Underlines indicate insertions and ~~strikeouts~~ indicate deletions.

49. (Amended) A method of forming an aluminum comprising line having a titanium nitride comprising layer thereon, the method comprising:

forming a first layer comprising at least one of elemental aluminum or an aluminum alloy over a substrate, at least an outermost portion of the first layer being formed at a first forming temperature of at least 400°C;

after forming the first layer and without letting the outermost portion of the first layer cool from the first forming temperature to a temperature below 360°C, forming a second layer by depositing titanium onto the first layer and forming therefrom during the depositing an alloy of titanium and the aluminum from the first layer, the alloy having a higher melting point than that of the first layer;

forming a third layer comprising titanium nitride over the second layer; and

forming the first, second and third layers into a conductive line.

-END OF DOCUMENT-